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"..... per litora spargite muscum,
Naiades, et circùm vitreos considite fontes:
Pollice virgineo teneros hìc carpite flores:
Floribus et pictum, divæ, replete canistrum.
At vos, o Nymphæ Crateridcs, ite sub undas;
Ite, recurvato variata corallia trunco
Vellite muscosis e rupibus, et mihi conchas
Ferte, Deæ pelagi, et pingui conchylia succo."
N. Parthenii Giannettasii Ecl. 1.

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I.—*On some Characters of* Lingula anatina, *illustrating the Study of Fossil Palliobranchs.* By William King, Sc.D., Professor of Mineralogy and Geology in the Queen's University, Ireland, and Queen's College, Galway.

[Plate II.]

The investigations which have led to the preparation of the present paper were begun with in order to ascertain the relationship between *Lingula* and *Trimerella*—a point which Mr. Davidson and myself considered necessary to be determined before completing the memoir we have in hand on the family typified by the last-named genus *.

* *Vide* Annals & Mag. Nat. Hist. 1872, x. p. 248.

I much regret that, owing to the distance by which we are separated, it was impossible for my friend and colleague, Mr. T. Davidson, F.R.S., to join with me in the investigations detailed in this paper. He has, however, aided me to such an extent that had it been otherwise the paper certainly would never have appeared. After much correspondence and trouble, he at last succeeded in procuring a number of specimens of *Lingula anatina* preserved in spirits. Some were supplied by Dr. L. de Koninck, Professor in the University of Liége; and others by Dr. C. Semper, Professor in the University of Würzburg, Bavaria, and Dr. G. Lindström, of Wisby, Gothland. To these gentlemen we join in recording our sincere thanks for their kind favours. We also feel it necessary to acknowledge our obligations to Prof. A. E. Verrill, of Yale College, for his valuable present of a bottle containing several fine specimens of *Discina lamellosa* and *Terebratulina septentrionalis*. These specimens have greatly assisted me in my researches on *Lingula*.

Notwithstanding that several highly valuable papers have appeared on the shell and animal of *Lingula anatina* *, my investigations have not been unsuccessful in bringing to light certain characters that have apparently escaped the notice of previous observers, or have been insufficiently understood by them. These and other characters are of so much importance in elucidating the shells of some imperfectly known fossils as to induce me to make them known to palæontologists.

Few, if any, shells exceed in interest those belonging to the genus *Lingula*. Occurring in rocks that were formed in what may be regarded in the present stage of geology as the oldest life-period of our planet, and being represented in every rock-system, as well as in existing seas, while most of its con-

* Mr. Davidson has kindly furnished me with most of the items of the following list of authors who have contributed to elucidate the anatomy of *Lingula*. I have made a few additions to the list, principally of authors who have described either fossil or recent species of the genus.

Bruguière. This author established the genus *Lingula* in the Encyclop. Méthodique, 1789.
Cuvier. "Mémoire sur les Lingules," Mém. du Muséum, vol. i., 1802.
Lamarck. Animaux sans Vertèbres, tome vi., 1819.
Owen. Transactions of the Zoological Society, vol. i., 1835.
Vogt. "Anatomie der *Lingula anatina*," Neue Denkschriften der allgemeinen Schweizerischen Gesellschaft für die gesammte Wissenschaften, Bd. vii., 1843.
Sowerby, G. B. Thesaurus Conchyliorum, 1846: recent Lingulas.
Owen. In Davidson's 'Introduction to the British Fossil Brachiopoda;' Monograph of the Palæontographical Society, 1853.
Huxley. Proceedings of the Royal Society, vol. viii., 1854.
Woodward. Manual of Mollusca, 1854.
Owen. Lectures on the Invertebrate Animals, 2nd edition, 1855.
Hancock. Transactions of the Royal Society, vol. cxlviii. 2nd part, 1855.
Gratiolet (P.). "Études anatomiques sur la Lingule anatine;" Journal de Conchyliologie, 1860.
Reeve. Conchologia Iconica, 1861: recent Lingulas.
Semper. Zeitschrift für wissenschaftliche Zoologie, vols. xi. and xiv., 1860, 1864.
Adams. Annals and Mag. Nat. Hist., vol. xi., 1863: Japanese Lingulas.
Davidson. Palæontographical Soc. Monographs; British Fossil Brachiopoda: Lingulas.
Morse. American Journal of Science, vol. l., 1870.
Dall. American Journal of Conchology, vol. vi. part ii., 1870.
Davidson. Proceedings of the Zoological Society of London, 1871: Japanese Lingulas.
Hall. Notes on some new or imperfectly known Forms among the Brachiopoda, &c., 1872: Lower Palæozoic Lingulas.

Other authors, as De Blainville, Deshayes, Captain King, Stimpson, Hinds, Broderip, and Salter, have more or less contributed information on *Lingula*. Bonin and Vivier are cited by Semper; but I have not been able to ascertain any thing respecting their work, except that it is anatomical.

temporary allies have become extinct, the genus may be looked upon as the longest-lived one of its class that is known. Still the remarkable fact is, that its various species do not offer, as in many other cognate genera, any striking variations of form; indeed it has been stated, though incorrectly, that certain existing species are undistinguishable from, or identical with, others characterizing different geological periods down to the Cambrians *.

Another subject of interest attached to the study of *Lingula* is, that throughout its entire existence the shell-substance of its various species has remained constantly and essentially corneous, the mineral, but more subordinate, constituents of this substance being principally phosphate of lime. In another corneous genus, *Discina*, there are the same paucity of striking test-features, and a *rôle* of equal duration. How different with the calcareous genera—for the most part short-lived, and marked with great diversity of specific forms!

The great pallial interspace, answering to the general cavity of the shell, is divided into three different compartments, each characterized by special features.

1. The most important compartment occupies a considerable portion of the posterior half of the shell-cavity, is bounded by a highly muscular wall or parietal band (figs. 1 & 2, *b*), and contains all the viscera, including the muscles. I propose to name this division the splanchnocœle †, or visceral chamber. With the exception of its frontal portion, which is prolonged in the dorsal valve (fig. 2; and fig 3, A), the anterior half of the present compartment is the widest, approaching to nearly the lateral shell-margins. Its posterior half is much reduced in width by a considerable incurvation of the corresponding portions of the wall: and its frontal prolongation causes the anterior outline to differ in the two valves—it being long and tapering in the dorsal, and obtusely rounded, with a slight median point, in the pedicle- or ventral one (fig. 1; and fig. 3, B). The differences in the outline of the chamber suggest the propriety of dividing its parietal band into four portions—posterior, post-lateral, ante-lateral, and anterior.

2. The anterior half of the pallial interspace is open all round (sides and front) except at its back, which is formed by the anterior parietal. It encloses the arms or brachial appendages

* Mr. Davidson, who has been erroneously credited with this statement, has not gone beyond expressing that "many fossil forms resemble in contour such shells as the large *L. tumida*, *L. ovalis*, and *L. anatina*." See Brit. Silurian Brachiopoda, p. 34.

† From *splanchna*, internal parts, and *cœlia*, cavity.

(fig. 2, *r*), and may therefore be called the brachiocœle * or brachial chamber. Its upper and under surfaces (dorsal and ventral lobes of the pallium or mantle) are highly vascular.

3. The sides of the splanchnocœle in its posterior half, as just stated, are rather strongly incurved, giving rise to two lateral spaces (fig. 1; & fig. 2, *m*), each bounded at the back or inner side by a post-latero-parietal, but open in front or the side corresponding with the adjacent margin of the shell. Possessing no special feature, I propose to give the name pleurocœles † to these spaces, simply from their position as side chambers. The two lobes of the mantle forming their upper and under surfaces are highly vascular.

The organs contained in the different chambers of most importance in the present paper are those that lie next to, or are inserted in, the valves—namely, the parietal band, shell-muscles, liver, genitalia, and some others; in addition to which the setal band and pedicle require to be described.

Parietal band (*b*).—The anterior portion, as already remarked, passes much further forward in the dorsal than in the ventral valve: it slopes backward from the former to the latter. Elsewhere the band passes directly or vertically between the valves. The incurvation of the post-lateral portions is somewhat the deepest in the dorsal valve: these portions are thicker and more muscular than the others.

In the dorsal valve there are two curving laminar muscular processes (fig. 2, *t*), each running somewhat vertically from the inner face of the ante-latero-parietals to the medio-longitudinal line of the shell. Huxley has named their homologues in *Terebratula* the gastro-parietal bands.

Liver (*c*).—This occupies the anterior portion of the splanchnocœle. Its surface-area is smallest in the pedicle-valve, and centrally situated. In the dorsal valve the corresponding area is more expanded, reaching nearly to the ante-latero-parietals: it is divided rather deeply, and in the transverse direction, by the gastro-parietal bands; while the resulting anterior division in its middle line is slightly grooved by the posterior portion of a medio-longitudinal shelly plate (fig. 2, *s*), which belongs to the interior of the valve.

Genitalia (*d*).—These, which occupy the remaining portion of the splanchnocœle, are distinguished from the liver by a larger pattern of granulation. Their largest surface-area is in the ventral valve.

As made known by previous observers, the mouth is situated in the prolongation of the anterior parietal at a little

* From *brachion*, arm.
† From *pleura*, side.

distance from the dorsal valve. The œsophagus, which passes between two muscles that attach themselves to the median shell-plate, is imbedded in the anterior division of the liver. The stomach, also similarly imbedded, is in connexion with the gastro-parietal band. The intestinal canal runs directly backward through the liver and genitalia: arrived at the posterior part of the splanchnocœle, and after making a few flexures, vertical and horizontal, it emerges at the ventral surface of the genitalia: next, running forward alongside the right post-latero-parietal *, it reaches the hind part of the adjacent ante-latero-parietal, penetrating this wall as a vent (fig. 1, *f*).

Shell-muscles. — There are five pairs, and an odd one. Three pairs (*j*, *k*, *l*) are *lateral*, having their members limited to the sides of the shell. One pair is *transmedian* (*i*), each member passing across the middle to reverse sides of the shell. One pair (*h*) has its members confined to nearly the *central* region. The odd muscle (*g*) occupies the umbonal cavity.

Lateral muscles.—In the dorsal valve one pair (*j*), which may be termed the *anterior*, is attached to the median plate, a member passing from each of its sides to the corresponding one in the opposite valve, where the splanchnocœle is widest. The second or *outside* pair (*l*) in the ventral valve has each member passing from the outer side of the central muscles to the same side in the dorsal valve, close to the posterior half of the ante-latero-parietal, and in the widest part of the splanchnocœle. The third or *middle* pair (*k*) springs from the ventral valve between the central muscles, each member passing to its corresponding side in the opposite valve, increasing much in size in the passage, and becoming inserted in front of, and inwardly to, the attachments of the muscles belonging to the last pair.

Transmedian muscles (*i*).—In the dorsal valve both members of this pair are implanted in the widest part of the splanchnocœle, one on the inner side of, and immediately adjacent to, the termination of the laterals *k* and *l*. Passing backward, each member crosses diagonally to the *reverse* side of the ventral valve; but while one preserves its unity, and terminates by inserting itself near the middle of the left post-latero-parietal, the other is divided in its passage, a division becoming

* In explanation of the terms *right* and *left side*, it is necessary to state that in placing either of the valves with its interior upward, and its beak nearest to the observer, the latter part is to be considered the posterior end, and the opposite margin the anterior end: this makes the side corresponding with the right hand the right one, and its opposite the left one.

inserted near the posterior, and another near the anterior, end of the opposite and corresponding parietal. The divided member embraces the undivided one.

The *umbonal* (figs. 1, 2, 3, 4, & 5, *g*) and *central* (*h*) muscles do not require any further description.

Lingula differs widely in its muscular system from most other Palliobranchs. The *umbonal*, if, as suggested by some, it really be two muscles that have become united, may be homologous with the posterior adductors in *Discina*. There is some probability that the *centrals* correspond to the only pair of adductors or valvulars occurring in the Terebratulids and Rhynchonellids. The *laterals* appear to have little in common, except their distinctive position, with either the pedicle or the cardinal muscles in the last-named families. As to the *transmedians*, they are essentially distinct from every muscle of other genera, even the allied *Discina* *—none in the latter ever connecting the two valves by their reverse or opposite sides.

It may be assumed that the central and umbonal muscles (*g*, *h*) effect the direct closing and opening of the shell, and that the laterals (*j*, *k*, *l*) enable the valves to move forward or backward on each other: but with respect to the transmedians (*i*), it is difficult to conceive otherwise than that they allow the similar extremities (the rostral) of the valves to turn from each other to the right, or the left, on an axis subcentrally situated—that is, between the anterior attachments of these muscles a little behind the medio-transverse line of the dorsal valve †. Still there are two important points, seemingly opposed to this view, that require to be considered.

Thus the position of the umbonal muscle appears to be capable of preventing any lateral displacement of the valves at

* I may on a future occasion describe the myology, and some other characters, of this interesting shell, as there is much to be added to, or amended in, the description given of it in papers already published. At present I may merely mention that the two small muscles inserted in the convex valve of *Discina*, between the adductors, appear to be the homologues of the *cardinals*, discovered by Quenstedt in *Rhynchonella* (pub. 1835), and by myself, without knowing the latter fact, in *Waldheimia* (pub. 1848). It would thus appear that *Discina* is closer in this respect to the Terebratulids and Rhynchonellids than to *Lingula*, in which these muscles are absent.

† Cuvier, in the 'Mémoires du Muséum,' vol. i. p. 69, 1802, was the first to notice the peculiar muscular character of *Lingula*. The muscles acting separately, he states, would be able to slide the valves in all directions; but he does not mention the precise mode of action of the transmedian muscles. The "sliding" motion of the valves has been strongly contested of late years; nevertheless, as will shortly be seen, the Cuvierian view is undoubtedly the true one.

the posterior end of the shell; but the objection seems to be met by the fact that this muscle is to some extent relaxable, as I have had no difficulty in turning aside the beak of either valve. Further, it might with some reason be assumed that the rostral extremity of the non-pedicle- or *unattached* valve possesses the greatest freedom of lateral motion; but the assumption requires the posterior terminations of the trans-median muscles to be inserted in the corresponding region of the valve: the contrary, however, is the fact. It is highly probable that careful observations on the habits of the animal of *Lingula* will remove these two objections: but whatever value attaches to them, or to the mode in which it has been attempted to diminish their force as a counter argument, I do not hesitate to regard the valvular movements, just contended for, to be quite in unison with the following facts:—

The umbonal muscle (*g*) is in no way fettered by the pedicle, or any other part. The shell is not only edentulous, but its hinge-margins are widely and totally separated from each other. The beaks have their margins persistently apart, even when the umbonal muscle is most rigid. The post-latero-parietals are highly muscular, necessarily permitting an unusual play of motion between the valves at their posterior extremity. The ordinary muscles (*h*, *j*, *k*, *l*), principally, are limited to the middle third of the valves—not, as in most Palliobranchs, to their posterior half. All these structural peculiarities are reciprocally related, and they are strictly consistent with the office herein ascribed to the transmedian muscles*.

* It will be seen by a reference to the 'American Journal of Science,' vol. l. pp. 103, 1870, that I am in complete accordance with the observations of Mr. Morse, who has observed living specimens of *Lingula pyramidata*, Stimpson, with the valves divaricated laterally at both ends, the axis of motion being evidently located near the centre of the shell. The idea with me was first suggested by Mr. Morse's observations.

Since the above was written I have been favoured by Mr. Davidson with an English translation of extracts from the "Reisebericht" of Professor C. Semper, published in the 'Zeitschrift für wissenschaftliche Zoologie,' vol. xi. 1860, and vol. xiv. 1864. Semper, who had favourable opportunities while residing at Zamhuanga, in South America, for studying living specimens of *Lingula anatina*, I find has anticipated the above observations by Morse. In the last of the volumes cited he mentions that it is "the habit of the animal of this species to displace the valves sideways when it is about to open them. This is never done suddenly or by jerks. The valves are at first always several times pushed to one side and back again on each other, at the same time opening gradually till at last they rest opposite to each other and widely apart." Some sketches sent by Dr. Semper to Mr. Davidson show the two valves crossing each other with a slight obliquity, as in Mr. Morse's figures. Neither of these observers, however, enters into any explanation as to how the lateral displacements are effected.

The various muscles, including the parietals, produce scars, often well seen in the valves of recent Lingulas. The scars are occasionally liable to become raised at their margin, giving them the appearance of individualized muscular fulcra or myophores. A specimen before me has the scar of one of the postlatero-parietals with its inner margin completely raised in the form of a plate. Such cases are evidently of abnormal formation; but they explain the origin of what may be assumed as normal cases—for example, *Lingula albida**, in which there are two of the same kind of plates. The attachments of the gastro-parietal bands produce in the dorsal valve two transverse impressions (corresponding to *t*), each of which passes behind one of the central muscle-scars, with a slight undulation, to nearly the middle line of the shell. In *Leptæna analoga* the myophore of the dorsal valve has a transverse laminar division, interrupted in the middle, which might be taken for the fulcrum of the gastro-parietal bands†; but this view could only be correct if the muscle-scars in the fossil referred to were, as in *Lingula*, situated in front of the laminar division, which is not the case.

As the shell-muscles of *Lingula* differ so widely from those characterizing most Palliobranchs, it cannot be expected that many fossils of the kind should exhibit scars indicating their possession of a similar myology. The remains of extinct species of *Lingula* occasionally show the characteristic scars, as may be seen by referring to Mr. Davidson's figure of *Lingula Lewisii*‡. In this species, however, the central muscles appear to be situated much further back than in *L. anatina*. So far my researches have failed in detecting in fossil Palliobranchs any scars that have been produced by muscles homologous with the transmedians of *Lingula*.

In comparison with the splanchnocœle of the Terebratulids and other shells allied to them, that of *Lingula* is not only more voluminous, but it has much thicker walls. In the former the parietals, being membranous and extremely thin§, leave little

* *Glottidia albida* of Dall (see 'American Journal of Conchology,' vol. vi. p. 157, pl. viii. fig. 2).

† King, 'Monograph of Permian Fossils,' pl. xx. fig. 7.

‡ British Silurian Brachiopoda, pl. iii. figs. 5 & 6.

§ The membranous parietals in the Terebratulids are occasionally strengthened by calcareous plates, so much so in *Terebratulina caput-serpentis* that they are crowded and beautifully tessellated with radial forms of the latter, as is also the case in the exposed or outer layer of the mantle where it covers the ovaries. It would therefore not surprise me to find that in some fossil species the visceral organs had been more or less protected by completely calcified parietes. My colleague and self, it is probable, may succeed in showing that the curious internal structures occurring in the typical Trimerellas served as receptacles for certain viscera.

or no impressions; and it is the same in a number of extinct families; from which it may be concluded that the relation of the latter to the Lingulids must be remote.

One reason why the splanchnocœle of *Lingula* is much larger than usual is that it contains the genitalia. These organs, or perhaps more correctly the ovaries, in the Terebratulids &c. are for the most part located in the brachiocœle, leaving impressions occasionally beautifully displayed in fossils; as may be seen in Davidson's figures of *Orthis Bailyana*, *O. rustica*, *O. calligramma* *, and several others, also in some recent species. The ovaries are generally located on each side of the splanchnocœle; it might therefore be inferred that the spaces similarly situated in certain fossils, as the Trimerellids, were the seat of these organs. Judging, however, from what is seen in *Lingula*, the spaces referred to may with more reason be taken to represent the pleurocœles.

Brachiocœle or brachial chamber.—The anterior prolongation of the dorsal surface of the splanchnocœle causes this chamber to be much smaller in the dorsal than in the ventral valve. Its most prominent contents are the brachial appendages (fig. 2, *r*), which are spiral, and originate in the anterior parietal, nearer to the dorsal than the ventral valve. The point or apex of the spiral is turned or directed toward the ventral valve, as in other recent Palliobranchs. The arms are too much removed from the inner surface of either valve to produce any impression, as is the case in certain fossils, notably *Davidsonia Verneuili* †, *Productus giganteus* ‡, and *Strophomena Jukesii* §. If similar impressions occurred in *Lingula* they would of course show that the arms had been turned towards the ventral valve: it is remarkable, however, that in the fossils referred to these organs appear to have been turned towards the opposite or dorsal valve.

The mantle-lobes forming the dorsal (upper) and ventral (under) surfaces of the chamber are well characterized by the vascular system. Both lobes are traversed by a pair of primary vessels (*p*) that run forward from the anterior parietal, a member from each of its sides: gradually approximating in their progress, without becoming united, they terminate, the dorsal pair at about a quarter of an inch, and the ventral pair at about twice this distance, from the margins of the chamber.

* British Silurian Brachiopods, pl. xxix. fig. 20, pl. xxxiv. fig. 16, pl. xxxv. fig. 12.

† Davidson, 'Introduction to Fossil Brachiopoda,' pl. viii. figs. 187 & 188.

‡ King, 'Monograph of Permian Fossils,' pl. xix. fig. 2.

§ Davidson, 'Monograph of British Silurian Brachiopoda,' pl. xxxvii. figs. 25 & 26.

From their inner side numerous secondary vessels (*q*) strike inwardly, with a backward curve, and meet in the middle line of the valves: others, larger than the latter (*q*), run off from the outer side of the primaries in an oblique forward direction, and parallel to one another; but they become suddenly and simultaneously constricted, and next somewhat rapidly attenuated, before reaching the shell-margins. Both the primaries and secondaries are slightly branched in the middle of the anterior part of the brachiocœle. The constriction of the outgoing secondaries forms a line (*v*) which runs round the margins from one side to the other of the anterior parietal: here the line is about an eighth of an inch from the margins, which distance is gradually increased to a quarter of an inch at the front. Both sets of secondary vessels give the interior of the pallial lobes a strongly plicated or ribbed character.

At its departure from the anterior parietal, each of the primary vessels sends off direct to the margin one or more branches, which, instead of stopping suddenly, like the outgoing secondaries, are abruptly turned backward, passing along the narrow space on the outside of the ante-latero-parietals, and entering the pleurocœles. These branches will be noticed again shortly.

The vessels of the brachiocœle, though prominent, do not produce such strong impressions on the inner surface of the valves as might be expected. Corresponding impressions are often more marked in recent Terebratulids, &c.; and they are frequently beautifully displayed in various species of extinct genera. The specimen of *Orthis striatula* * originally belonging to Dr. de Koninck, and now in the British Museum, and several other fossils that have been figured by Davidson, show them very distinctly; also *Leptæna analoga* †, and *Camarophoria multiplicata* ‡. In the last fossil the vascular impressions even show a median line, which seems to correspond with the mid rib inside the vessels in *Lingula* §.

Pleurocœles or side chambers. — Reverting to the main

* Introduction to Fossil Brachiopoda, pl. vii. fig. 133.

† Monograph of Permian Fossils, pl. xx. figs. 6 & 7.

‡ Ibid. pl. viii. figs. 6 & 7.

§ The mid rib is the *septum* of Semper, who has discovered that on one side of it the blood flows forward, and on the other side backward. Failing to detect any contractile organs, or the so-called "hearts," and from certain evidences, he is of opinion that the circulation of the blood is effected by the action of cilia lining the inside of the vessels. Each of the primary vessels appears to be divided at its origin. Assuming this interpretation to be correct, and adopting Semper's opinion, one division may serve for the outflowing, and the other for the inflowing current.

branches of the primary vessels that pass backward external to the ante-latero-parietals,—on entering the present compartments they separate a little, and pass on, anastomosing here and there, to the posterior part of the valves. Both on their inner and outer sides spring a number of offshoots: the outer pass direct to the pallial margins; and the inner (*n*), some curving backward, and others forward, pass to the post-latero-parietals. The main branches define, as it were, the outer boundary of each pleurocœle; while the inner offshoots are often sufficiently prominent to give an irregularly puckered character to its upper and under (pallial) surfaces.

The next structure to be described may be not inappropriately introduced under the present head, though it belongs equally to the brachiocœle.

Both pallial lobes have a slightly raised flattened band (*u*) from an eighth to a quarter of an inch in width, the widest part being in front: it runs round the pallial margins, from which its outer edge (*w*) is distant about one sixteenth of an inch. The attachment of the band is strongest at its inner edge (which nearly corresponds with the line of vascular constriction, *v*): the outer edge, somewhat thickened or corded, is so slightly attached that there is no difficulty, by inserting a fine blade underneath, in separating it from the mantle; while further inward the attachment is even slighter, permitting the band to be raised in its entire width except along its inner edge. Numerous long setæ are well known to characterize the pallial margins of the Palliobranchs. In *Lingula* these parts (*x*) have their basal portion, about one third of their length, imbedded in the band: they pass nearly to its inner edge, and lie so close to each other, side by side, as to form a divisional plane or an upper layer in it. On raising the upper layer, the cause of its slight attachment is at once perceived; for the setæ are tied down to the mantle only along the base of the corded margin of the band.

Although the *setal band*, as it may be termed, runs along the pallial margins in their entire extent, the course of the setæ in the ventral valve is interrupted in one part—that is, in the region of the pedicle (figs. 1 & 4): there is no interruption in the opposite part of the dorsal valve *. The band in both valves gradually thickens on approaching the hinge; at which part it is puckered, and somewhat reduced in width (fig. 4, *u*), the incrassation giving it a prominent appearance. In the ventral valve, where the setæ are interrupted, the attachment of the outer edge is discontinued (fig. 3, *u*), the band being

* In *Discina lamellosa* the setæ are not interrupted in either valve.

simply attached by its inner edge, now widened, to the narrow space between the root of the pedicle and the postparietal.

In the pleurocœles the inner edge of the setal band corresponds to some extent with the line formed by the main posterior branches of the vascular system; consequently both structures contribute to form the outer boundary of these chambers. In the brachiocœle the same edge (*v*) is in immediate connexion with the line formed by the constriction of the outgoing secondary vessels (*v*); and it becomes thicker and more prominent, appearing as if irregularly frilled, in passing to the front of the valves. The rapidly attenuated vessels, previously noticed, cross obliquely, with a slight forward curve, the setal band, giving it, especially its inner edge, a somewhat plicated character. The band is also crossed by what appear to be incised lines, or striæ, directed less obliquely than the latter vessels, and which become subdivided near its outer edge.

In none of the specimens of *Lingula anatina* that have passed under my observation is there any well-marked impression of the setal band. Aged individuals with thick valves very probably show something of the kind; and it can readily be imagined that in such the muscular attachment of the inner edge of the band will produce a submarginal scar running round both valves. Usually the posterior half of the valves is the thickest: and it is on the outside of the spaces that represent the pleurocœles (belonging to this half) that impressions may occasionally be observed, consisting of an obscurely defined line that runs backward from each side of the splanchnocœle, where it is widest, to the hinge. Traces are seen of irregular impressions (which answer to the offshoots) striking from both sides of the above line, especially on the above spaces. Often, however, these spaces are plain, each being bounded inwardly by the scar, generally strong, produced by the post-latero-parietal, and outwardly by the obscurely defined line already mentioned. The two spaces in both valves are occasionally connected at their posterior end by a faint linear scar passing behind the umbonal muscle, and which is evidently due to the attachment of the setal band. Taken together, the posterior part of the band and the two pleurocœles are represented by a large arch-shaped impression, the crown of which is linear and the sides are dilated.

In fossil Palliobranchs a posterior arch-shaped impression is uncommon. Mr. Davidson and myself are prepared to show that it occurs in the Trimerellids. Doubtless it is present in extinct species of *Lingula*. Recently Mr. James Hall, who has

kindly favoured me with gutta-percha impressions of it, has made known a singular fossil (a small one), to which he has given the generic name of *Lingulops*, on the idea that it is a Lingulid. The posterior half is furnished with a broad semicircular impression of nearly uniform width, with a singularly scolloped inner edge, reminding one of a Moorish arch. I suspect this style of edging was produced by the symmetrical form and arrangement of the vascular offshoots that traversed the pleurocœles. The same vessels in *Lingula* possess a certain degree of symmetry that favours this suspicion. *Discina* shows in each valve what might be taken for an arch-shaped scar; but this is produced by the posterior adductor muscles. *Obolus* is characterized by some remarkable scars in the cardinal region, particularly a pair having a member curving outwardly from each side of the hinge. Until recently I suspected the latter to be the homologue of the arched impressions of *Lingula*; but I now feel convinced that it was due, as in *Discina*, to the posterior adductors.

Attention must be directed in the next place to the pedicle (fig. 4, *y*), its attachments and accessories (figs. 3, 4, & 5).

Beginning with the latter, the most important is the deltidium (fig. 5, a); which, when properly developed (not usually so), is a shallow triangular depression, having a flattened space (c) on each side. The lateral spaces, which form the hinge-area as usually known, are marked transversely by epidermal lines of growth*. The deltidium is marked both longitudinally and transversely by numerous fine lines, the latter being the strongest. Immediately bordering each of its sides there is a ridge (b) slightly raised above the level of the areal spaces, and marked with arched epidermal lines. The anterior end of the deltidial ridges is, as it were, pushed up, thereby producing a small rude callosity (b') : in front of the latter there is a roundish depressed scar (e). The ridge-callosities are no doubt insignificant; nevertheless they may be the rudiments of important structures. Apparently they have become so far developed in *Lingula Lesueuri* as to serve to articulate the valves. If I am correct in putting this interpretation on the "two depressions or pits in the cast seen close to the extremity of the beak," and represented in Mr. Davidson's figure of it†, this species cannot belong to the genus in which it has been placed; as teeth seem to render a pair of transmedian muscles (essentials in *Lingula*) unnecessary.

* There is an area in the non-pedicle-valve marked with transverse epidermal lines; but it is not broken by a deltidium, merely by a faint longitudinal groove.

† Monograph of British Silurian *Linguleæ*, p. 43, pl. i. figs. 2 & 3.

On the anterior edge, which slopes forward, a finely marked lineated impression (d') is seen passing from one deltidial ridge-scar to the other. The lines of this impression run parallel with, and somewhat resemble, those which cross the deltidium, so that the difference between the two is difficult to make out: indeed both might be readily confounded.

The deltidium is a variable structure in Palliobranchs generally; and its modifications are far from being properly understood. As regards the deltidium in the genus under consideration, one circumstance is remarkable: it has been in a great measure overlooked; at least I can find little, or rather no, notice of it in the writings of previous observers. It is this oversight which led the late J. W. Salter to institute his genus *Lingulella*, which he typified with the Cambrian *Lingula Davisii*, under the belief that its "pedicle-groove" and "hinge-area" do not characterize any species of the old Bruguièrian genus. *Obolus* and some apparently related genera*, also the Trimerellids, are the only shells I am acquainted with that have a structure resembling the deltidium of *Lingula*. In the latter family it is a conspicuous object, having attained a maximum development, which is equally the case with the deltidial ridges.

The pedicle (fig. 4, y), which is cylindrical, consists of two concentric layers, the innermost of which (fig. 3, h) is muscular, and the other (g) corneous. Near the proximal extremity it becomes suddenly reduced in diameter, and at the same time compressed into the form of an oval, the long axis of which corresponds to the width of the shell. At the reduced part it is attached by one of the flattened faces of the corneous layer to the deltidium (fig. 3, g, a), the transverse and longitudinal lines of which are marks of its attachment. The anterior edge or extremity (fig. 3, d) of the same face is inserted immediately in front of the deltidium—that is, along the border of the hinge-slope, the faint lineated impression previously noticed being produced by its insertion. The sides or angles of the *anterior edge* are converted into tendinous lobes, which are individually attached to each of the ridge-scars (e): the pressure of the lobes against the end of the deltidial ridges evidently gives rise to the ridge-callosities. The corneous layer is not present on the opposite face of the pedicle, but makes its appearance a little within the opening of the beaks of the shell.

The muscular layer (h), passing in advance of the corneous one under the form of a much compressed cylinder, is rooted in the narrow space between the hinge-slope and the attach-

* *Discina* may be included, as its deltidium, although remarkably modified, appears to agree with that of *Lingula*.

ment of the setal band; as may be seen by effecting the outer margin (here not attached) of the latter organ, and cutting the pedicle across at the root (fig. 5, h).

It is scarcely to be expected that any well-defined scar could result from the attachment of the muscular layer, considering the immediate proximity of such scar to those produced by other organs (setal band and corneous layer, see fig. 3), and the liability of all the scars to become confluent through the incremental creeping backward or forward, as the case may be, of the organs respectively producing them. Were it otherwise, the attachment of the setal band and the corneous layer ought to give rise to two subparallel lineated scars, more apart in the middle than at the ends; while between them there ought to be an ellipsoid, produced by the muscular portion of the pedicle (see fig. 5, h, i). For the reasons stated, the last kind of scar cannot be expected to occur: traces may; which leads me to imagine that certain lines occasionally to be seen running along the hinge-slope may represent it. An elliptical scar, similarly situated, has been detected by Mr. Davidson and myself in testiferous specimens of certain Trimerellids: it is due, we suspect, to the inner muscular layer of the pedicle.

Conclusion.—My researches connected with *Lingula* strongly enforce on me the belief that it represents a group of Palliobranchs differing in several very important points from most others of its class. From being furnished with spiral arms, it has been placed by Dr. Gray in his "subclass Helictopoda," along with *Rhynchonella*, *Spirifer*, *Productus*, and some other related genera; but as all these belong, from certain evidences which I could adduce, to the great *non-aniferous* section, whereas *Lingula* possesses an anal vent, it is clear that Gray's "subclass" would be made a more natural one by removing this genus from it.

As regards the great sections to which allusion has been made, they appear to me to constitute the two primary and most comprehensive ones into which the Palliobranchs may be divided. I would therefore propose that one section should comprise all the *non-aniferous* families belonging to Gray's subclasses Ancylopoda and Helictopoda, with the name *Clistenterata**; and that the other should include the *aniferous* families *Lingulidæ* and *Discinidæ*, and be designated *Tretenterata*†.

Confining myself to the last section, I shall briefly notice the features which distinguish it from the first one:—

* From *cleistos*, shut, and *entera*, intestine.
† From *tretos*, perforated.

Aniferous.
Splanchnocœle large, and lying *within* the pallial margins.
Setal band passing continuously round the pallial margins.
Genitalia principally enclosed within the splanchnocœle.
Muscular peculiarities.
Pedicle not serving as a base of attachment for any muscles*.

Judging from what Semper and Morse have already made known respecting *Lingula anatina* and *L. pyramidata*, it seems highly probable that the section is also distinguished to some extent by its respiratory apparatus.

The Tretenterates appear to admit of being grouped under two divisions, respectively represented by *Lingula* and *Discina*, as the latter genus is strikingly differentiated by its muscular system, pedicle-characters, pallial vessels, and setal band.

EXPLANATION OF PLATE II.

All the figures are diagrammatic, particularly figs. 3 & 5.

Fig. 1. Ventral or pedicle-valve. Splanchnocœle: this chamber in both valves is bounded by the parietal band, *b*, which I have made to consist of four portions—*posterior* (behind the part marked *g*), *post-laterals* (at the incurvations), *ante-laterals* (at the ecurvations), *anterior* (extensions in front): *c*, liver; *d*, genitalia; *e*, intestine; *f*, termination of intestine; *g*, umbonal muscle; *h*, central muscles; *i*, transmedian muscles; lateral muscles (*j*, anteriors; *k*, middles; *l*, outsiders): *m*, pleurocœles; *n*, vessels of pleurocœles (exaggerated): brachiocœle—all the anterior half of the valves outside the anterior parietal; *p*, primary vessels of brachiocœle; *q*, secondary vessels of brachiocœle (those passing from the inner side of the primaries may be called *in-goers*, and those on the outer side *out-goers*); *u*, setal band (the pedicle is not represented, in order to show the continuation of this band in the rostral region); *v*, inner edge of setal band—answering also to the line of vascular constriction; *w*, outer edge of setal band; *x*, setæ.

Fig. 2. Dorsal valve. *r*, arms or brachial appendages (relative position and direction of spirals merely shown); *s*, medio-longitudinal shell-plate; *t*, gastro-parietal bands (attached to slightly raised shell-ridges in the valve, and which are represented under *t*). All the other parts are lettered as in fig. 1.

Fig. 3. Medio-longitudinal section of cardinal region of both valves. A, dorsal valve; B, ventral or pedicle-valve: a, deltidium; d, cardinal or hinge-slope: g, corneous or external layer of pedicle—the lower division (or, rather, under face of the pedicle) is attached to a and d′; h, muscular or inner layer of pedicle; i, central hollow of pedicle: *b*, posterior parietal of splanchnocœle; *g*, umbonal muscle; *u*, setal band; *x*, setæ.

Fig. 4. Cardinal region of pedicle-valve. *y*, pedicle (its attached end is covered by the setal band, *u*); *b*, posterior parietal (a horizontal

* In *Discina*, contrary to what has been stated, the pedicle, which is an external organ, has no proper muscular connexion with the interior of the shell; the connexion is chiefly vascular and neural.

section); *g*, umonbal muscle (a horizontal section); *u*, setal band; *w*, outer edge of setal band; *x*, setæ.

Fig. 5. Cardinal region of pedicle-valve. a, deltidium; b, deltidial ridges; b′, deltidial callosities, slightly developed; c, areal spaces; d′, lineated impression, produced by anterior end of corneous layer of pedicle (see fig. 3, d); e, lobe-scars produced by tendinous lobes of corneous layer of pedicle; h, cross section of muscular or inner layer at root of pedicle; i, central hollow of pedicle: *b*, posterior parietal; *g*, umbonal muscle; *u*, setal band, which has its outer edge (*w*) effected to show the parts d, h, i (the corneous layer is removed to show the lineated impression made by the anterior end of its lower division—see fig. 3, d, g).

II.—*On two new Species of* Gummineæ, *with Special and General Observations.* By H. J. Carter, F.R.S. &c.

[Plate I.]

In a glass jar bearing the inscription "H.M.S. 'Porcupine,' No. 3*a*, lat. 48° 31′ N., and long. 10° 03′ W., depth 500 faths., and muddy bottom," which must have been just outside the so-called "chops" of the English Channel, is an oblong specimen about $2\frac{1}{2} \times 1\frac{1}{4} \times \frac{3}{4}$ inch, consisting of a mass of dead *Lophohelia prolifera*, over which has grown a *Farrea*, which, having shared the same fate, had become partially infested, both inside and out, with three other sponges bearing spicules which indicate that they belong respectively to *Dictyocylindrus*, Bk., *Desmacella*, Sdt., and *Reniera*, Sdt., together with a *Cliona* whose habitat was inside the stems of the *Lophohelia* and its fenestral openings on the surface of the latter, all of which have finally become enveloped in a *Gummina*, whose fleshy substance now forms the greater part of the mass (Pl. I. figs. 1 & 2).

With the exception of the *Lophohelia* and *Farrea*, all appear to be new species.

As the three infesting sponges are merely parasitic growths of small dimensions and without definite form, I shall only be able to characterize them by their complements of spicules respectively. The *Cliona*, too, having lived in the interior of the *Lophohelia*, necessitates a similar description, while the *Gummina*, which, as before stated, forms the greater part of the mass, claims our first and chief consideration.

It is with great pleasure that I embrace this opportunity of calling attention to a class of sponges which has been very little studied, especially in England; and having found in the British Museum, through the aid of Dr. Gray, another species, which came from Port Jackson in New South Wales, I shall thus be able to give the results of my examination of this as well as the